MISR Level 2 Aerosol/Surface Products Quality Statement May 13, 2005

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Quality Designations:

- **Stage 2 Validated:** AEROSOL - aerosol optical depth over heterogeneous surfaces and dark water
- **Stage 1 Validated:** LAND - surface radiative parameters: BRF, HDRF, DHR, and BHR
- **Provisional:** LAND - LAI/FPAR parameters
- **Beta:** AEROSOL - aerosol optical depth over homogeneous surfaces other than dark water; Aerosol micro-physical properties: aerosol Angstrom exponent, aerosol single-scattering albedo, aerosol particle size and shape fractional amounts.

Please bear in mind that products designated as anything less than "Stage 1 validated" may change significantly between versions.

MISR maturity level definitions

The statements here apply to **MISR Level 2 Aerosol Products, Version F08_0017 or greater**, and to **Land Surface Products, Version F05_0017 or greater**, effective until further improvements to MISR software are made. See the Versioning Page for an in-depth explanation of the differences among MISR product versions. Quality statements covering earlier time periods are accessed through links at the bottom of this page.

The evaluation of product quality is ongoing. Please read the summary words of caution, if you have not done so already.

The MISR Level 2 Aerosol/Surface software which generated these products is believed to be functioning well, except as noted below. This statement highlights major known problems and issues with the products, as well as planned upgrades that are not yet implemented.

Aerosol | Land | Ocean

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1. MISR Level 2 Aerosol Product (a.k.a. AS_AEROSOL, MIL2ASAE)

[This product is generated by the MISR PGE9 executable code]

The MISR Aerosol Product is reported over 17.6 km regions, using data from up to 36 channels in a 16 x 16 array of 1.1 km radiance pixels. Algorithm pre-processing executes a range of data-screening operations, and provided a minimum number of pixels pass all the tests, an aerosol retrieval is performed. Different retrieval approaches are used over land and water, as discussed in the references cited. Detailed validation of MISR-retrieved aerosol optical depth has been performed, and aerosol microphysical property validation is underway, as described below.

1.1 MISR Aerosol Product Maturity

All aerosol parameters now have "Provisional" status with the exception of:

Status	Parameter
Stage 2 Validated	RegBestEstimateSpectralOptDepth, RegMeanSpectralOptDepth
Beta	ChisqHomog, OptDepthHomogCalcPerBand, ChisqHomogCalcPerBand, Reg*AngstromExponent, Reg*SpectralSSA, Reg*SpectralOptDepthFraction, Reg*NumberFraction, Reg*VolumeFraction
Not implemented	RegSfcRetrOptDepthUnc, OptDepthDWCalcPerBand,

	OptDepthOTACalcPerBand, ChisqAbsCalcPerBand, RelHumidProfile, RelHumidProfileSrc, StratAerFlag, StratAerOptDepth, StratAerOptDepthSrc, CirrFlag, CirrOptDepth, CirrOptDepthSrc

Product users should be aware that the aerosol models used in the retrieval analyses provide a practical means of deriving optical depth, and ***optical depth has been validated***, as described below. However, it is more difficult to obtain reliable ground truth data to compare with MISR total column aerosol type (particle microphysical property) retrievals; ***validation of retrieved particle microphysical properties is underway***, using a combination of AERONET sun photometer and detailed field campaign data. As the MISR retrieval process matures, the thresholds used in the algorithm acceptance criteria will be reduced, yielding more tightly constrained results.

The **Stereo Height** parameter in the MISR Level-2 Cloud Stereo product may be of interest to MISR aerosol product users as well. It gives stereo-derived heights of clouds and aerosol plumes to about 0.5 km accuracy, whenever elevated features are distinct in multiple MISR views. For aerosols, this occurs most frequently in aerosol source regions.

1.2. Aerosol Optical Depth

Available at Stage 2 Validated Quality Level

The best estimate of aerosol optical depth (RegBestEstimateSpectralOptDepth) and the average over the optical depths of all successful aerosol models (RegMeanSpectralOptDepth) are Stage 2 Validated maturity level for Version 16 and higher. This applies to aerosol optical depth over ***both water and land***, which are produced using different retrieval approaches [*Martonchik et al*, 2002, and references therein]. The variable AlgTypeFlag in the RegParamsAer part of the AS_AEROSOL product reports which approach was used for the aerosol retrieval in a given 17.6 km region: 1=dark water; 3=heterogeneous land, 253=fill. A full description of AlgTypeFlag is given in the MISR Product Specifications Document, Rev K, December 12, 2003 (PDF), page 223.

[Note: For Aerosol algorithm V3.2 (aerosol product 0016) and earlier, RegBestEstimateSpectralOptDepth has been the same as RegMeanSpectralOptDepth. In V3.3 (aerosol product 0017) and higher, if RegMeanSpectralOptDepth is missing, RegBestEstimateSpectralOptDepth will be filled in with the average of successful RegMeanSpectralOptDepth in a 3x3 patch of 17.6 regions, and the standard deviation of this quantity will be reported as the RegBestEstimateSpectralOptDepth uncertainty.]

A global comparison of retrieved aerosol optical depths for coincident MISR and AERONET data was performed for the time period December 2000 through November 2002 [*Kahn et al.*, 2005a], The comparison shows that overall, 63% of the MISR-retrieved aerosol optical depth (AOD) values in the green band fall within 0.05 or 20% * AOD of AERONET, and about 40% are within 0.03 or 10% * AOD. As expected, correlation coefficients are highest for maritime cases (~0.9), and lowest for bright desert sites (still greater than ~0.7). This PDF document of tables shows uncertainties as a function of wavelength, and binned by season and expected aerosol air mass type, as described in *Kahn et al.* [2005a].

Additional MISR optical depth validation, yielding similar results, has been performed over bright deserts [*Martonchik et al.*, 2004; *Christopher and Wang*, 2004], over the continental United States [*Liu et al.*, 2004], over coastal water [*Redemann et al.*, 2005; *Schmid et al.*, 2003], and using sun photometer data to evaluate MISR and MODIS results over land and water [*Abdou et al.*, 2005].

1.3. Aerosol Particle Microphysical Properties

Available at Beta Quality Level

Aerosol ***Angstrom exponent*** is now available at the Beta quality level. The aerosol Angstrom exponent parameters are computed as a least-squares linear fit to the logarithm of the aerosol optical depths evaluated at all four MISR wavelengths. Aerosol ***single-scattering albedo*** is now available at the Beta quality level. Aerosol particle ***size and shape fractional amounts*** are also available at the Beta quality level. They are given at each MISR wavelength, as the fraction of optical depth at that wavelength attributed to the small (< 0.35 micron radius), medium (0.35 to 0.70 micron radius), and large (> 0.70 micron radius) size categories, and the spherical and non-spherical shape categories. Fractions based on assessed particle number and particle volume in each category are reported in the variables "RegBestEstimateNumberFraction" and "RegBestEstimateVolumeFraction". Each of these variables contains five values, corresponding to the fractions of small, medium, and large sizes, and fraction optical depth assigned to spherical and to non-spherical particles, respectively. The first three values add to one, as do the last two.

The user should be aware that MISR ***sensitivity to aerosol microphysical properties is reduced when mid-visible aerosol column***

optical depth is below about 0.15. The degree to which this occurs depends on aerosol and surface type, and is being quantified as part of the MISR aerosol microphysical properties validation. MISR-retrieved aerosol optical depth accuracy, however, does not depend heavily on particle properties, especially under low optical depth conditions [*Kahn et al.*, 1998; 2005a].

1.4. Dependence on Aerosol Climatology Product (ACP)

The quality of the aerosol product depends upon the quality of the Aerosol Climatology Product (ACP). The ACP contains assumed component aerosol particle properties, and mixtures of these components. For each 17.6 km region, the retrieval algorithm selects *all* mixtures in the ACP that produce spectral-angular radiances in a forward radiative transfer model that meet a set of chi-squared criteria [*Martonchik et al.*, 1998; *Diner et al.*, 2001].

The number of mixtures that pass all the chi-squared test criteria is reported in the Aerosol Product as "NumSuccAerMixture". Note that "BestFit" (or "LowestResid") quantities are reported ***even if the residual for that mixture is too large to pass the success criteria*** (so NumSuccAerMixture is zero) this is used to study the choices made for success criteria. The "AerRetrSuccFlag" also reports whether any mixtures met the success criteria (a value of "7"), as well as other possible algorithm conditions (See: MISR Data Products Specification document, Revision K, December 2003 (PDF), p. 224).

[If you need to know the actual chi-squared thresholds and other parameters used for a given run of the algorithm, these are reported as configuration parameters in the "Annotation text", which is stored in the Aerosol Product hdf files. For example, there is a sub-section in this text called "(2) Parameters that apply to the dark water aerosol retrievals," in which the threshold choices for the chi-squared absolute, geom, spec, and maxdev tests are reported. A description of the dark water tests themselves is given in *Kahn et al.*, (1998; 2001b). The corresponding heterogeneous land aerosol retrieval chi-squared threshold values are given in "(4) Parameters that apply to heterogeneous aerosol retrievals," and are documented in *Martonchik et al.*, (1998). See also the MISR Level 2 Aerosol Retrieval ATBD (PDF)].

The ACP was updated in product **Version 0016**, with a new aerosol component dataset and a new mixture dataset. The changes involve ***adding spherical pollution and biomass burning particle analogs having lower single-scattering albedo*** than available in the previous version [*Kahn et al.*, 2005a], ***more realistic mineral dust*** analogs [*Kalashnikova et al.*, 2005a], and a ***richer set of bi-modal and tri-modal mixtures***. Refer to the ACP quality statement for further information.

1.5 Dependence on Terrestrial Atmosphere and Surface Climatology (TASC)

The MISR TASC (Terrestrial Atmosphere and Surface Climatology) dataset provides monthly, global climatological information on conditions of the area being observed by the MISR instrument, used during the aerosol retrieval process, Included are ***surface pressure*** for evaluating top-of-atmosphere Rayleigh scattering radiances, climatological ***ozone and water vapor*** for minor spectral band corrections, and ***near-surface wind speed*** to estimate ocean surface white cap area. Sensitivity studies indicate that in most circumstances, retrieval uncertainties introduced by using monthly 1x1 degree climatological values of these quantities are smaller and often more difficult to constrain than other uncertainties, such as retrieval climatology component particle definitions, that are receiving higher priority in the MISR validation effort. [*Kahn et al.*, 2001a;b]

1.6 Cloud Screening

Cloud screening is performed prior to aerosol retrieval. The MISR Standard Products include ***three separate MISR-derived cloud Masks***:

RCCM -- Radiometric Camera-by-camera Cloud Mask in the "Level 1B" product (*Zhao and Di Girolamo*, 2004).

SDCM -- Stereo-Derived Cloud Mask in the "Level 2 TC- STEREO" product (*Moroney et al.*, 2002).

ASCM -- Angular-Signature Cloud Mask in the "Level 2 TC- CLASSIFIERS" product (*Di Girolamo and Wilson*, 2003).

These are used in aerosol retrieval pre-processing according to logic described in the MISR Level 2 Aerosol Retrieval ATBD, ***along with radiance angular smoothness, and spatial correlation*** tests [*Martonchik et al.*, 2002 (PDF)].

(The results of these tests are not reported explicitly in the product. Rather, a cascade of tests is performed in pre-processing, and the data are examined only until a test fails, at which point that test is called out in the RetrAppMask parameter in the Level 2 AS_AEROSOL product. [See Product Specifications Document, Rev K, December 12, 2003 (PDF), page 216].)

The current masking approach does not detect some clouds; validation and refinement are underway. Detection blunders are common ***near the edges of well-defined clouds***, causing the water or land aerosol retrieval algorithm to be used improperly. These blunders manifest themselves as large values for the aerosol optical depth (> 2). Also, current schemes have difficulty ***discriminating cloud from optically thick dust*** aerosol plumes in some cases.

Validation and refinement of the aerosol algorithm cloud masking approach is a high-priority activity, currently underway. Since the quality statement update on November 27, 2002, for product version 0011, improvements to the cloud detection scheme have been implemented, which have eliminated the majority of the cloud-edge blunders. Work is continuing on the algorithms to further reduce the blunder rate. For example, several MISR-based methods of distinguishing condensate clouds from optically thick dust aerosol plumes are under investigation. See the RCCM Quality Statement for further details.

1.7. Aerosol Optical Depth Retrieval Notes and Issues

1.7.1. Known Retrieval Blunders over Land

Retrieval blunders sporadically occur for ***terrain types having low spatial contrast, most notably bright deserts and snow/ice*** fields. They are manifested as anomalously large values of optical depth (>2) that appear to be randomly scattered throughout an area. Increased numbers of blunders occur over snow/ice fields as a consequence of inadequate cloud screening. Blunder elimination is a high-priority ongoing task, and a spectral contrast angular-signature cloud mask (ASCM; *DiGirolamo and Wilson*, 2003) is being implemented to help reduce these errors.

1.7.2 Optical Depth Uncertainties Over Land

Estimates of aerosol ***optical depth uncertainty over land*** have been improved by applying more stringent constraints on the heterogeneous land aerosol retrieval algorithm. Previous uncertainty estimates were unduly large due to lack of use of spectral information.

1.7.3 Optical Depth Uncertainties Over Water

As a result of refined MISR low-light-level radiometric calibration, the ***uncertainty in MISR-retrieved aerosol optical depth over dark water has been reduced to about 0.025 at mid-visible wavelengths***, based on preliminary comparisons with near-coincident AERONET sun photometer measurements [*Kahn et al.*, 2005b; *Diner et al.*, 2004]. This represents a 40% improvement for the Version 16 of the aerosol product relative to earlier versions.

1.7.4 Algorithm Updates

The aerosol retrieval algorithms described in the MISR Level 2 Aerosol Retrieval ATBD (Revision E, April 2001) have been modified and improved, based on initial analyses of the data. The next release of this document will include an updated description of these algorithms.

1.7.5 Experimental Aerosol Algorithm Over Homogeneous Surfaces

A new algorithm that retrieves aerosol properties over homogeneous surfaces is included. However, due to its experimental nature, results from this algorithm are reported for diagnostic purposes only. Affected fields in the aerosol product are ChisqHomog, OptDepthHomogCalcPerBand, and ChisqHomogCalcPerBand.

1.7.6 Spectral-angular "Shape Mask" Over Land

Beginning with **Version 0012** of the aerosol and surface products, an algorithm refinement that uses a ***spectral similarity condition in the angular shape of surface HDRF*** has been implemented, based on the idea that for natural surfaces, the angular shape should be fairly similar across the MISR wavelengths [*Diner et al.*, 2005]. This upgrade has resulted in three tangible benefits: (1) far fewer optical depth outliers occur over land, (2) correlations with AERONET aerosol sun photometer data are quantitatively improved, and (3) the quality of surface products is markedly enhanced.

1.7.7 Some Fields Not Available in the Current Product

The following fields in the aerosol product are not currently computed, and should not be used: RegSfcRetrOptDepthUnc; OptDepthDWCalcPerBand; OptDepthOTACalcPerBand; ChisqAbsCalcPerBand; RelHumidProfile, RelHumidProfileSrc, StratAerFlag, StratAerOptDepth, StratAerOptDepthSrc, CirrFlag, CirrOptDepth, CirrOptDepthSrc.

2. MISR Level 2 Land Surface Product (a.k.a. AS_LAND, MIL2ASLS)

[This product is generated by the MISR PGE9 executable code]

PRODUCT MATURITY

The following surface parameters now have "Stage 1 Validated" status: LandHDRF, LandBHR, LandBRF and LandDHR. All other surface parameters have "Provisional" status with the exception of BiomeBestEstimateQA,which is not yet implemented.

AEROSOL DEPENDENCY

The land surface product relies on the aerosol product for atmospheric correction information. Therefore, the quality of the land surface product depends upon the quality of the aerosol product. The atmospheric correction information used in the land surface retrievals is reported in RegSfcRetrOptDepth and related fields in the aerosol and land surface products.

RELIABILITY OF LAND SURFACE REFLECTANCE VALUES DEPENDENT UPON AEROSOL OPTICAL DEPTH MAGNITUDE

At the current time land surface retrievals, particularly those with low surface albedo, should be considered most reliable when the aerosol optical depths are small (< 0.2). For higher albedo areas, such as deserts, good results are obtained for optical depths < 0.4. Thus, it is recommended that users examine the RegSfcRetrOptDepth field in the land surface product as part of their assessments of the surface parameters. This field is the aerosol optical depth at 558 nm (green band), used in the surface retrieval process. Other parameters which indicate the quality of the surface retrieval include LandBHRRelUnc (ratio of BHR [Bi-Hemispherical Reflectance] uncertainty to BHR value) and LandHDRFUnc (HDRF [Hemispherical-directional Reflectance Factor] uncertainty), which are derived from the uncertainty in the retrieved aerosol optical depth. It can be assumed that these uncertainty products also apply to the DHR [Directional Hemispherical Reflectance] and BRF [Bidirectional Reflectance Factor] surface products, respectively. Inspection and analysis of these products, for both dark and bright areas, indicates that they adequately represent the uncertainty associated with their respective products, and therefore are good indicators of product quality. Some sporadic but obvious retrieval blunders do occur, however, for areas that are bright and have little contrast (e.g., deserts and snow/ice fields) and these are easily seen in the images as anomalously bright reflectances. Further refinements in the quality of the aerosol retrievals over land are planned for future releases and these are expected to result in improvements in the surface retrieval blunder rate and product quality at larger optical depths.

QUILTING EFFECT IN LAND SURFACE REFLECTANCES

Most of the retrieved land surface reflectances are reported at a 1.1 km x 1.1 km spacing, whereas the retrieved aerosol optical depths are computed at a coarser 17.6 km x 17.6 km spacing. It is assumed that aerosol amount is constant over any particular 17.6 km region, which results in values of aerosol optical depth that are inherently discontinuous going from one region to an adjacent one. Therefore, the atmospheric correction process, using the coarse resolution aerosol data with the fine resolution reflectance data, occasionally produces a distinctive "quilting" effect in the directional surface reflectance imagery, i.e., a discernable block pattern. Imagery from the extreme off-nadir cameras at 446 nm (blue band) is particularly prone to this effect. The aerosol optical depth discontinuities are due to both real variation in aerosol amount on spatial scales smaller than the 17.6 km spacing and to intrinsic uncertainties associated with the aerosol retrieval process. Because of improvements to the land aerosol retrieval algorithm, the resulting inter-regional optical depth variability, much of which was an artifact of the retrieval process, has now been significantly reduced, thus mitigating, to a large extent, the "quilting" effect. The magnitude of any remaining "quilting" effect is well described by the surface reflectance uncertainty parameters, mentioned in the previous section.

FILL VALUES IN LAND SURFACE REFLECTANCES

Land surface reflectances are computed separately for each MISR spectral band. In some cases, the land retrievals succeed in one MISR band, but not another. This can cause visualization problems when viewing a composite image of land surface reflectances which contains spectral bands for both successful and unsuccessful retrievals. This occasional algorithm failure in certain bands (notably blue and/or red) is a high priority item for investigation and repair.

CORRECTION TO MODIFIED RPV MODEL BRF PARAMETERS (R0, K, B)

Version 0016 and earlier of the modified RPV (MRPV) model BRF parameters (r0, k and b; a.k.a. BRFModParam1, BRFModParam2, and BRFModParam3) are affected by a software error, which results in incorrect output for those parameters. The error is present at all latitudes, but is most severe (and visually obvious) at geographical regions where MISR is viewing nearly perpendicular to the principal plane (which is within a relatively narrow belt about the equator and about 3-5 blocks wide, shifting latitude-wise with season). This error is corrected in version 0017 and later products.

LAI/FPAR AVAILABILITY AT PROVISIONAL QUALITY LEVEL

The LAI/FPAR [Leaf Area Index / Fractional absorbed Photosynthetically Active Radiation] fields are now of "Provisional" quality. The software which computes leaf-area index (LAI) and fraction of photosynthetically active radiation (FPAR) uses Land Surface Reflectances (BHR and BRF) as input. Two spectral bands, red and near-infrared, and 7 view directions are currently used to produce LAI and FPAR.

The quality and spatial coverage of LAI and FPAR depend on the quality and coverage of the Land Surface Reflectances (BHR and BRF). Surface reflectances whose uncertainties exceed an acceptable level of 20% result in algorithm failure. The data analysis indicates that uncertainties in the MISR BHR of dense vegetations at red and blue spectral bands can substantially exceed the acceptable level. At these wavelengths, dense vegetations exhibit low reflectances. As indicated in section "RELIABILITY OF LAND SURFACE REFLECTANCE VALUES DEPENDENT UPON AEROSOL OPTICAL DEPTH MAGNITUDE", reliability of land surface retrievals can be low in this case. High uncertainties in BHR retrievals over dark surfaces, therefore, can result in algorithm failure, reducing the number of successful retrievals. With a probability of about 70%, uncertainties in retrieved LAIs do not exceed uncertainties in the MISR Surface Reflectances (BHR and BRF). Inspection and analysis of the LAI/FPAR product indicate that the successfully retrieved LAI/FPAR values follow regularities expected from physics.

Considerable attention was also paid to characterizing the quality of the LAI/FPAR parameters. The quality of LAI/FPAR retrievals can be assessed through examining LAINumGoodFit1 and LAINumGoodFit2 accompanying the product; that is, LAINumGoodFit1*LAINumGoodFit2>0 indicates highest retrieval quality; LAINumGoodFit1>0 and LAINumGoodFit2=0 - intermediate quality.

The operational version of the algorithm does not archive low quality retrievals (LAINumGoodFit1=0 and LAINumGoodFit2>0). For more details on the performance of the provisional LAI/FPAR algorithm as well as how to interpret LAIMean1 and LAIMean2 as a function of biome type, the users is referred to Hu et al., Performance of the MISR LAI and FPAR Algorithm: A Case Study in Africa, Remote Sens. Environ, Vol. 88, Issue 3, 15 December 2003, pp. 324-340 (PDF).

IMPROVED LAI FOR GRASSES AND BROADLEAF CROPS

Validation of version 16 and earlier of the MISR LAI product suggests the algorithm substantially overestimated LAI values in grasses and broadleaf crops. A recalibrated algorithm has been incorporated into version 17 and later. Validation of version 17 suggests the MISR LAI product to correctly accommodate structural and phenological variability. The version 17 product is accurate to within 0.5 LAI in herbaceous vegetation and savannas and is an overestimate by about 1 LAI in broadleaf forests.

BHRPAR and DHRPAR AVAILABILITY AT PROVISIONAL QUALITY LEVEL

The BHRPAR and DHRPAR fields are now of "Provisional" quality (PDF).

SOME LAND SURFACE FIELDS NOT AVAILABLE

The following fields in the aerosol product are not currently computed, and contain fill only: BiomeBestEstimateQA.

3. MISR Level 2 Ocean Surface Product (a.k.a. AS_OCEAN, MIL2ASOS)

OCEAN NOT YET AVAILABLE

The Ocean Surface product, which contains surface reflectance properties over ocean, has not yet been implemented. It is unavailable at this time.

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Also see:

- Statement dated November 28, 2004 for MISR Level 2 Aerosol/Surface Products from November 28, 2004 to May 12, 2005.
- Statement dated March 10, 2004 for MISR Level 2 Aerosol/Surface Products from March 10, 2004 to November 27, 2004.
- Statement dated February 13, 2004 for MISR Level 2 Aerosol/Surface Products from December 1, 2003 to March 9, 2004.
- Statement dated August 13, 2003 for MISR Level 2 Aerosol/Surface Products from August 13, 2003 to November 30, 2003.
- Statement dated January 25, 2003 for MISR Level 2 Aerosol/Surface Products from January 25, 2003 to August 12, 2003.
- Statement dated November 27, 2002 for MISR Level 2 Aerosol/Surface Products from November 27, 2002 to January 25, 2003.
- Statement dated September 25, 2002 for MISR Level 2 Aerosol/Surface Products from September 25, 2002 to November 26, 2002.
- Statement dated July 29, 2002 for MISR Level 2 Aerosol/Surface Products from July 29, 2002 to September 24, 2002.
- Statement dated April 15, 2002 for MISR Level 2 Aerosol/Surface Products from April 15, 2002 to July 28, 2002.
- Statement dated September 27, 2001 for MISR Level 2 Aerosol/Surface Products from September 27, 2001 to April 14, 2002.
- Statement dated March 30, 2001 for MISR Level 2 Aerosol/Surface Products from March 30, 2001 to September 26, 2001.
- Statement dated February 16, 2001 for MISR Level 2 Aerosol/Surface Products from February 16 to March 29, 2001.